ECON 222A
Macroeconomic Theory I

Long-Run Economic Growth

Lecture 11

Announcements

- Tutorial on February 28th 7.00-8.30pm in Dunning 14: only exercises
- Midterm on March 1st 6.30-8.30pm WLH 205
- Class on March 2nd is cancelled
- Room change for March 4: Dupuis 215
- Second Problem set is ready to collect

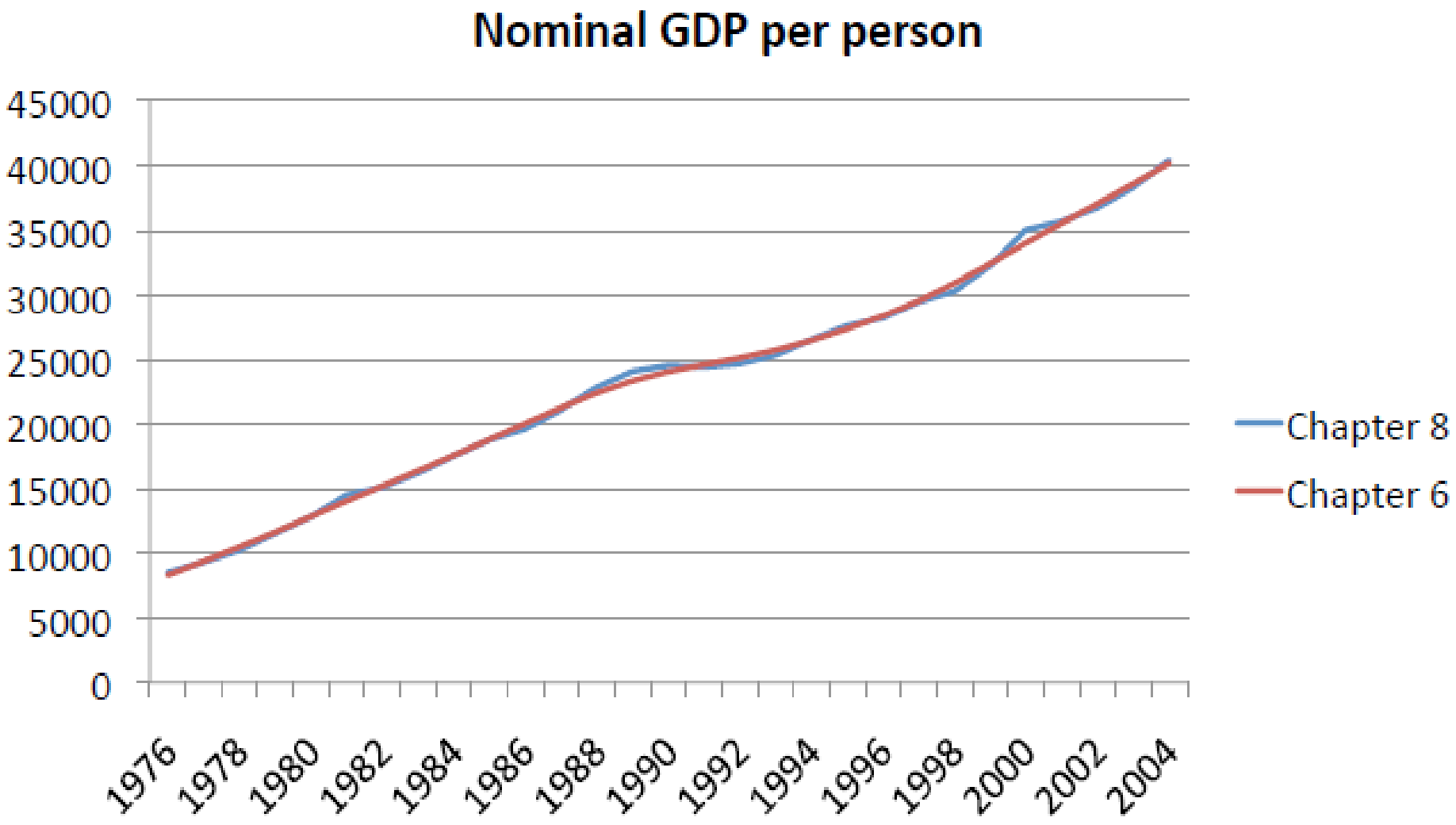
Today's Lecture

- Long Run Economic Growth

– warning: tends to be the toughest part of a second year macro course

– it's fascinating

Growth Vs. Cycles



Some Facts about Growth

- There is enormous variation in per capita income across economies.
- Rate of economic growth vary substantially across countries.
- Some countries experience “growth miracles” and others “growth disasters”.
- Developed countries experience comparable annual growth rates.

TABLE 6.1

Economic Growth in Eight Major Countries, 1870–1998

	Levels of Real GDP per Capita				Annual growth rate
Country	**1870**	**1913**	**1950**	**1998**	**1870–1998**
Australia	3 645	5 715	7 493	20 390	1.4%
Canada	1 695	4 447	7 437	20 559	2.0
France	1 876	3 485	5 270	19 558	1.8
Germany	1 821	3 648	3 881	17 799	1.8
Japan	737	1 385	1 926	20 084	2.6
Sweden	1 664	3 096	6 738	18 685	1.9
United Kingdom	3 191	4 921	6 907	18 714	1.4
United States	2 445	5 301	9 561	27 331	1.9

Note: Figures are in US dollars at 1990 prices, adjusted for differences in the purchasing power of the various national currencies.

Source: Data from Angus Maddison, *The World of Economy: A Millennial Perspective*, Paris: OECD, 2001.

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Average GDP (World)

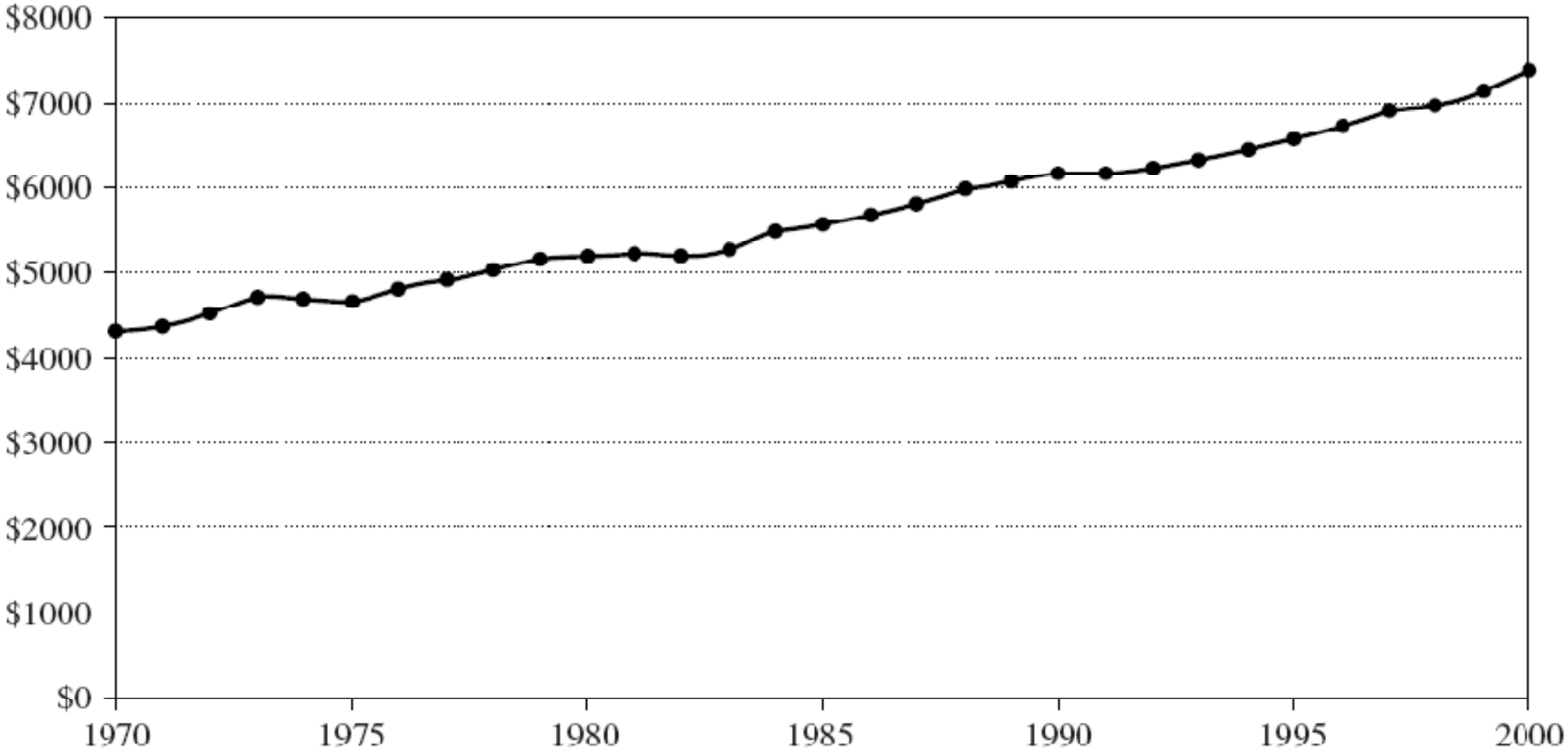


Figure I.4
World per capita GDP, 1970–2000. World per capita GDP is the sum of the GDPs for 126 countries (139 countries after the collapse of the Soviet Union) divided by population. The sample of 126 countries is the one used in Sala-i-Martin (2003a) and accounts for 95 percent of the world's population.

Growth Rates

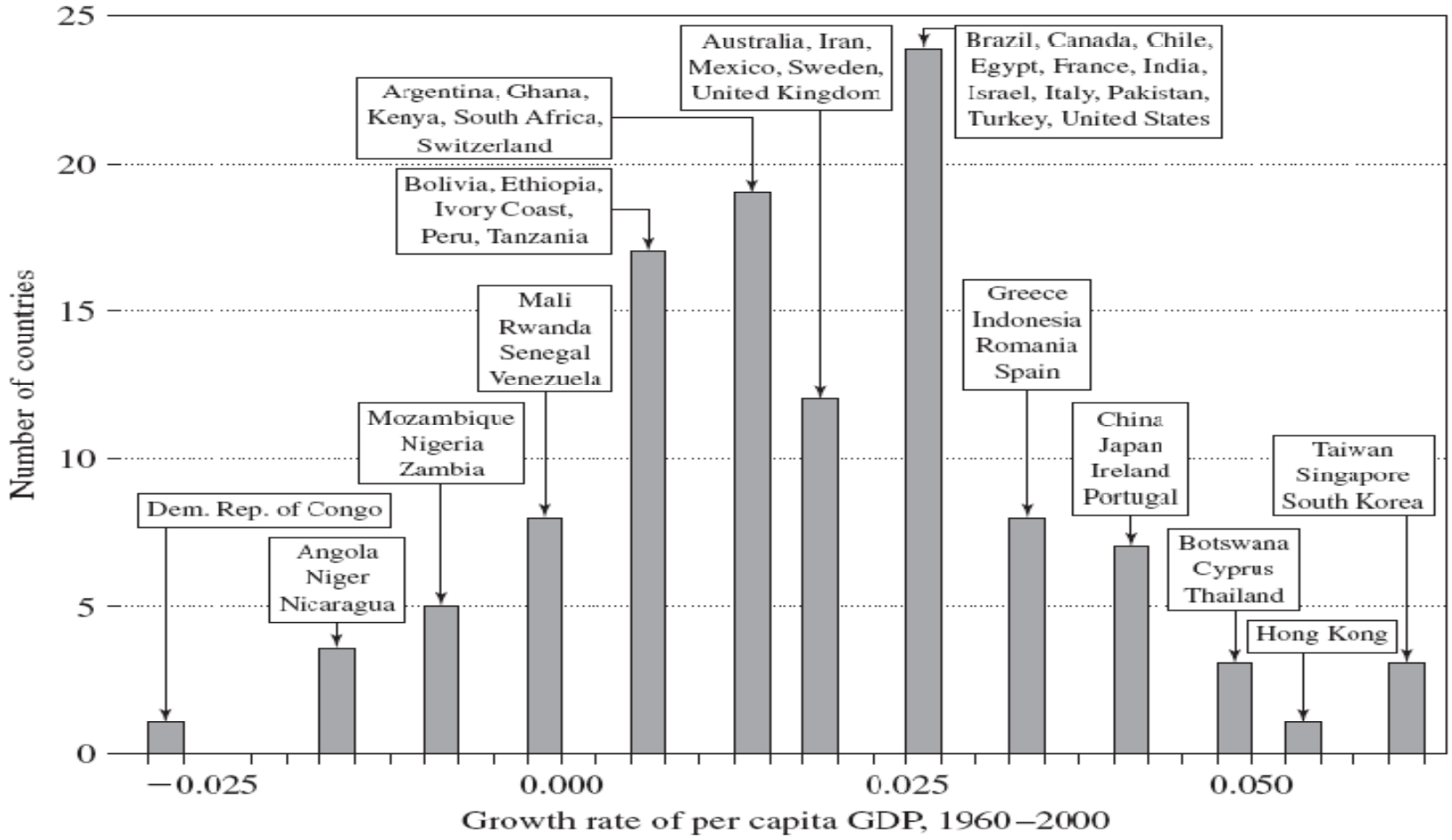


Figure I.3
Histogram for growth rate of per capita GDP from 1960 to 2000. The growth rates are computed for 112 countries from the values of per capita GDP shown for 1960 and 2000 in figures I.1 and I.2. For Democratic Republic of Congo (former Zaire), the growth rate is for 1960 to 1995. West Germany is the only country included in figure I.1 (for 1960) but excluded from figure I.3 (because of data problems caused by the reunification of Germany). Representative countries are labeled within each group.

Poverty Rates

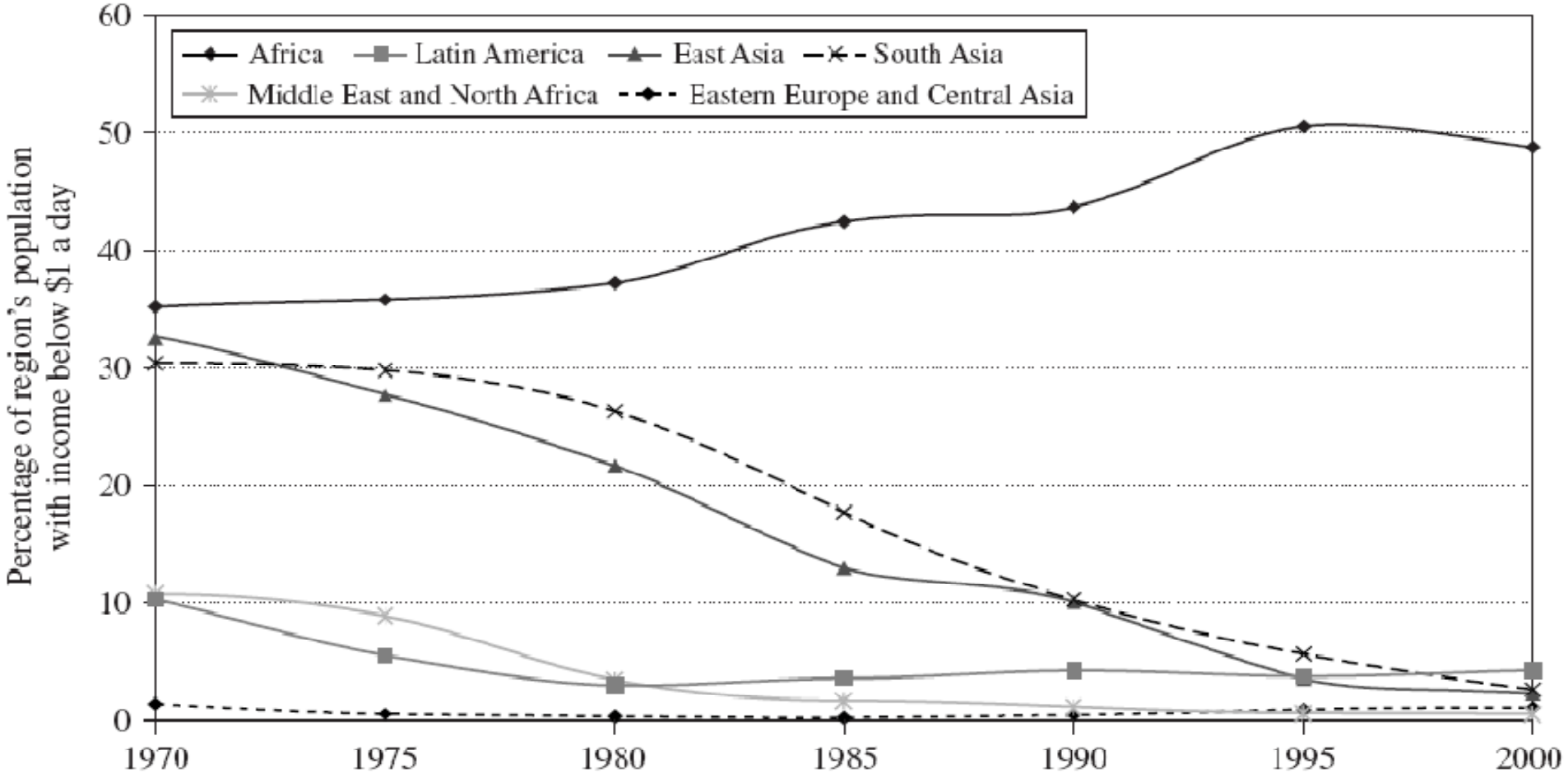


Figure I.8
Regional poverty rates. The graphs show the fraction of each region's population with income below the poverty line. The regions are the ones defined by the World Bank: East Asia, South Asia, Latin America, Africa, the Middle East and North Africa (MENA), and Eastern Europe and Central Asia. Source: Sala-i-Martin (2003a).

Convergence?

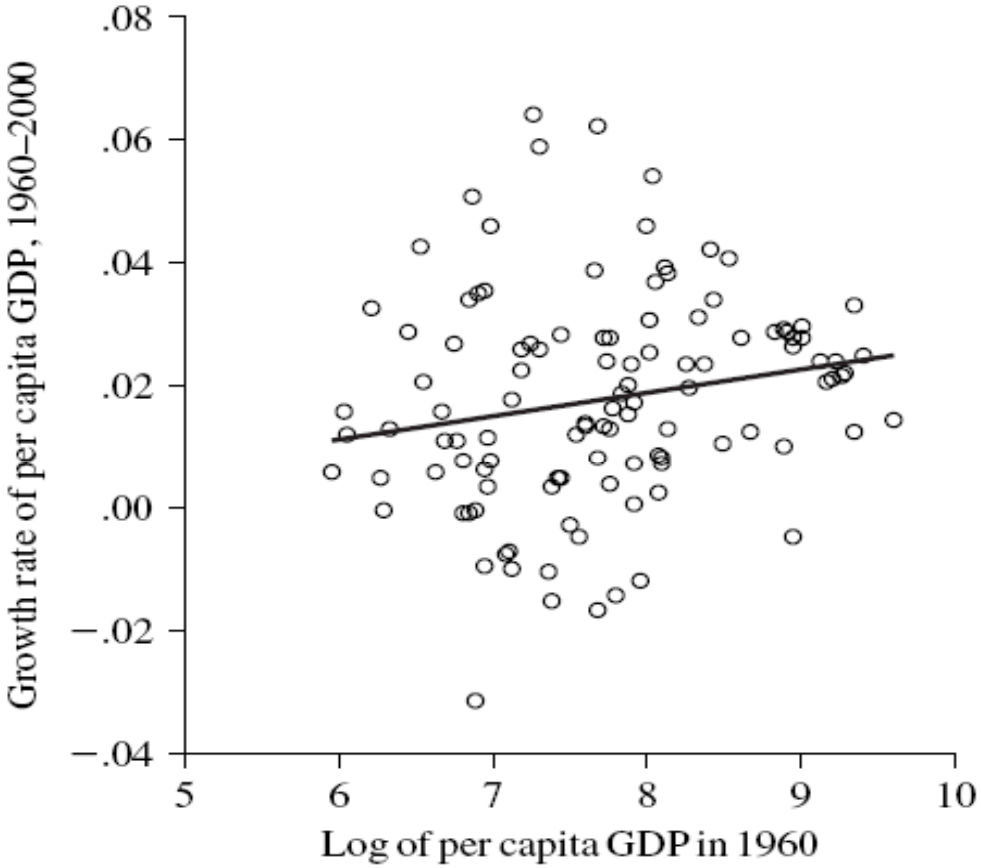
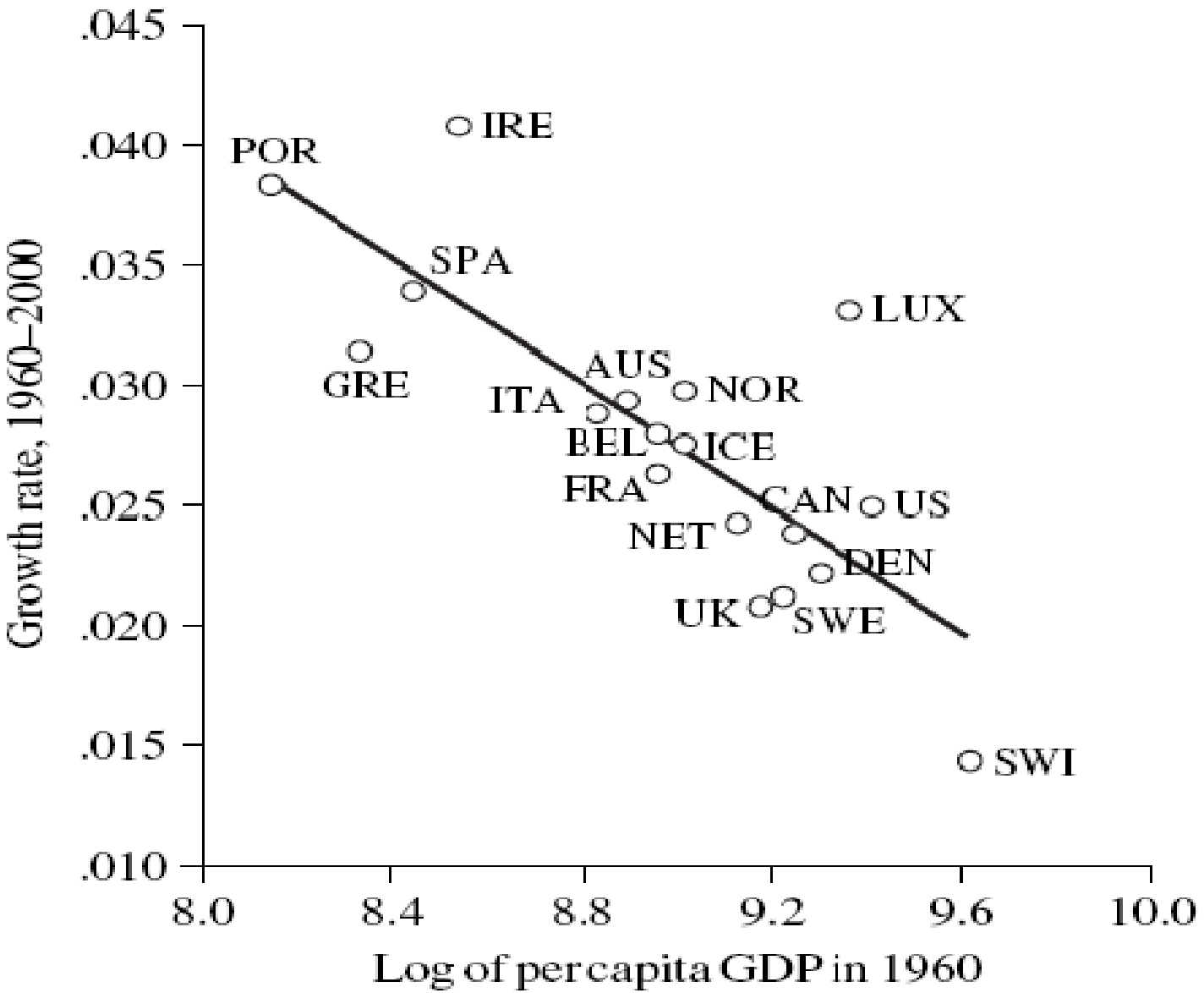


Figure 1.7
Convergence of GDP across countries: Growth rate versus initial level of real per capita GDP for 114 countries. For a sample of 114 countries, the average growth rate of GDP per capita from 1960 to 2000 (shown on the vertical axis) has little relation with the 1960 level of real per capita GDP (shown on the horizontal axis). The relation is actually slightly positive. Hence, absolute convergence does not apply for a broad cross section of countries.

Convergence!



Why Do These Things Happen?

- Economists are still working on it.
- There are some competing theories, but the literature has progressed a lot in the last 25 years.
- We are going to see a model which is the starting point of every growth theory and that provides many insights.
- Savings, investment and capital accumulation will be heart of the matter.

Key Results

- Productivity is key, saving and investment rates (in human and physical capital) also matter.

- Small growth differences can lead to large difference in average incomes in the Long Run.

- Institutions, government policy and inequality also seem to matter.

Growth Accounting

- Start with a simple formula for figuring out which factors account for growth.
- It comes from the production function

$$Y=AF(K,N)$$

- Life was static before (at a point in time), now we are considering time explicitly:

$$Y_t=A_tF(K_t,N_t)=A_t(K_t)^{\alpha}(N_t)^{1-\alpha}$$

Growth Accounting

- The growth accounting equation:

$$\frac{\Delta Y}{Y} = \frac{\Delta A}{A} + \alpha_K \frac{\Delta K}{K} + \alpha_N \frac{\Delta N}{N}$$

- $\Delta Y/Y$ is the rate of output growth;
- $\Delta K/K$ is the rate of capital growth;
- $\Delta N/N$ is the rate of labor growth;
- $\Delta A/A$ is the rate of productivity growth.

Growth Accounting

- α_K = elasticity of output growth wrt capital (roughly 0.3)
- α_N = elasticity of output growth wrt labor (roughly 0.7)
- If *A* increases by 1% then *Y* increases by 1%
- If *K* increases by 1% then *Y* increases by less than 1% (diminishing *MP*)
- If *N* increases by 1% then *Y* increases by less than 1% (diminishing *MP*)

So, growth comes from:

- Productivity Changes (remember: we don't observe *A*)
- Capital Stock Changes (we do observe *K*)
- Labor Changes (we do observe *N*)
- Changes in the α's can have only a temporary effect: bounded between 0 and 1 (we do observe the factor shares)

TABLE 6.3

Sources of Economic Growth in Canada (Percent per Year)

	(1) 1891–1910	(2) 1910–1926	(3) 1926–1956
Source of Growth			
Labour growth	1.8	1.0	0.6
Capital growth	0.8	0.3	0.6
Total input growth	2.6	1.3	1.2
Productivity growth	0.8	1.2	2.7
Total output growth	**3.4**	**2.5**	**3.9**

	(4) 1962–1973	(5) 1974–1986	(6) 1987–2003
Source of Growth			
Labour growth	2.2	1.5	1.1
Capital growth	1.4	1.1	0.8
Total input growth	3.6	2.6	1.9
Productivity growth	1.8	0.5	1.0
Total output growth	**5.3**	**3.1**	**2.9**

Source: Adapted from the following: 1891–1956: N. Harvey Lithwick, *Economic Growth in Canada: A Quantitative Analysis*, 2nd ed., Toronto: University of Toronto Press, 1970; 1962–2003: Statistics Canada, CANSIM II series v1078498, v246119, v3860085, and Labour Force Historical Review, 2004. The Lithwick findings do not incorporate the recent Urquhart revisions to pre-1926 GDP.

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Solow Residual

- Can calculate technological progress $\Delta A/A$ as output growth not attributable to growth in inputs (as a *residual*):

$$\frac{\Delta A}{A} = \frac{\Delta Y}{Y} - \alpha_K \frac{\Delta K}{K} - \alpha_N \frac{\Delta N}{N}$$

Ex: *Y* growth 5%, *K* growth 5%, *N* growth 3% $\alpha_N = \alpha_K = 0.5$.
Solve for A growth? 1%

- Growth accounting simply describes, but does not explain growth: e.g. Growth increased because *K* stock grew, but why did *K* grow? because of Saving and Investment decisions.

Questions

- Is there a relationship between a country's Long Run standard of living and fundamentals like savings and population growth?
- Does Long Run growth speed up, slow down or stabilize?
- Do poor countries have a chance to catch up with rich ones?

Neoclassical Growth Model (Solow-Swan)

- Components of the Model:

- N_t = number of workers available in year t
- Y_t = output produced in year t
- I_t = total investment in year t
- C_t = consumption in year t

Neoclassical Growth Model: Assumptions

- Workforce is a fixed proportion of population (ignore movements in/out of *LF*)
- Population (and Workforce) grow at constant rate *n*

$$N_{t+1} = N_t(1 + n)$$

- Closed economy (*NX*=0 and S^d=I^d)

- There is no government (*G*=0) which simplifies Income-Expenditure Identity to *Y*=*C*+*I*, or

$$C_t = Y_t - I_t$$

Neoclassical Growth Model

- Trick: Write everything in per-worker terms (gets rid of N in production function)
- $y_t = Y_t/N_t$ = output per worker in year t
- $c_t = C_t/N_t$ = consumption per worker in year t
- $k_t = K_t/N_t$ = capital stock per worker in year t
- k_t is also called the capital-labor ratio

Neoclassical Growth Model

- Getting the per-worker production function, $f(.)$; start from the production function

$$Y_t = A_t F(K_t, N_t)$$

- Set $A=1$(for now) and divide the production function by N_t:

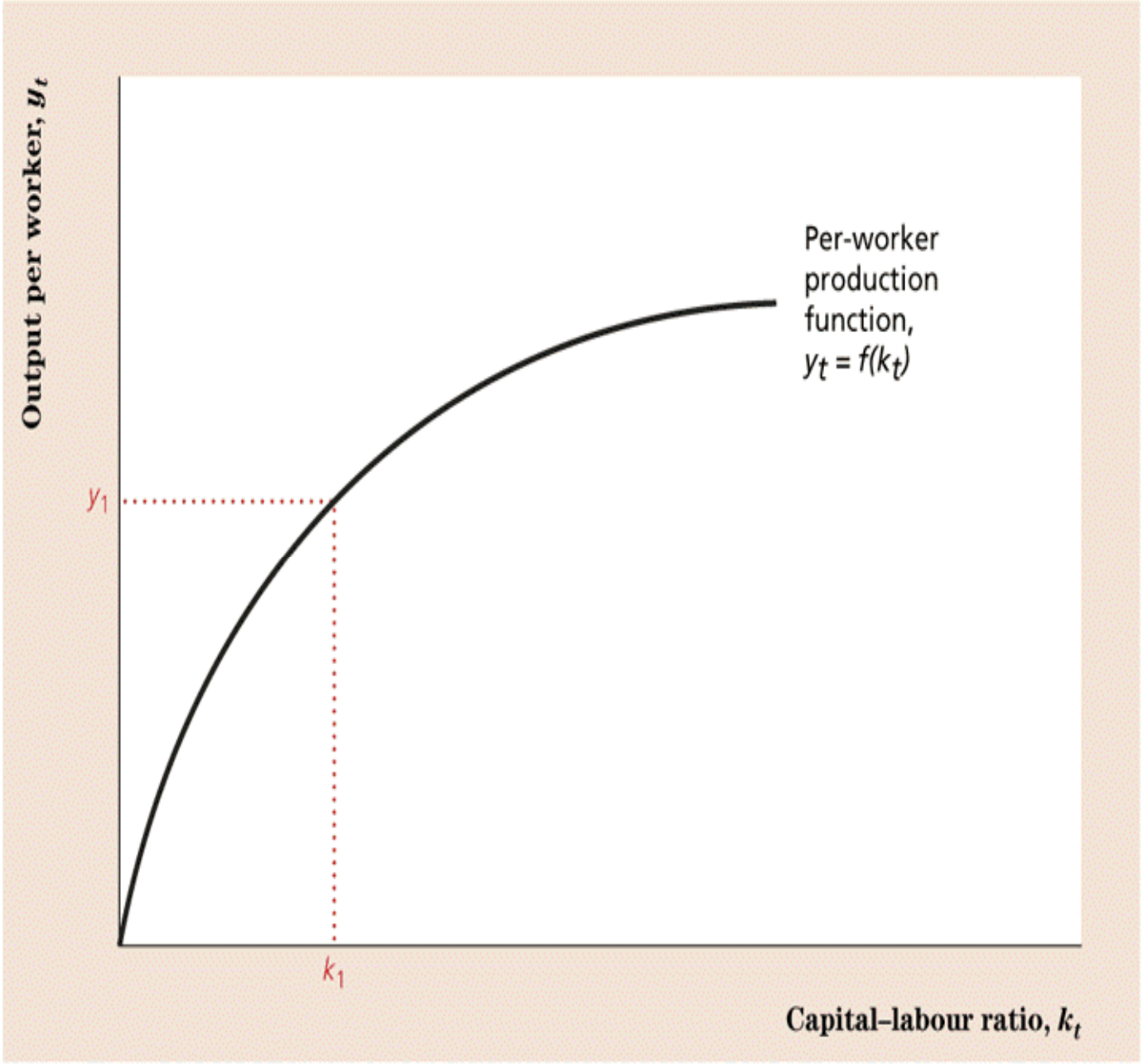
$$y_t = (K_t)^{\alpha}(N_t)^{-\alpha} = (k_t)^{\alpha}$$

- Same properties as the aggregate production function but different units. It slopes up, and shows diminishing *MPk*

FIGURE 6.1

THE PER-WORKER PRODUCTION FUNCTION

The per-worker production function, $y_t = f(k_t)$, relates the amount of output produced per worker, y_t, to the capital–labour ratio, k_t. For example, when the capital–labour ratio is k_1, output per worker is y_1. The per-worker production function slopes upward from left to right because an increase in the capital–labour ratio raises the amount of output produced per worker. The bowed shape of the production function reflects the diminishing marginal productivity of capital.



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Equilibrium Concept: Steady State

- Equilibrium in this model is called the steady state: over time we have constant **per worker** values of y_t, c_t, and k_t
- In the absence of productivity growth the economy reaches a steady state in the long run.
- Since y_t, c_t, and k_t are constant in a steady-state, Y_t, C_t, and K_t all grow at rate n, the rate of growth of the workforce.

- Consider savings and investment decisions

Equilibrium Concept: Steady State

- Savings are simple since we suppose that people save a constant fraction of their income

$$S_t = sY_t$$

S_t : aggregate national savings in year t

s: savings rate, between (0,1)

- Relaxing this doesn't change the results, if given the choice in the model that's what people would do

Equilibrium Concept: Steady State

- Investment
- Equation for evolution of *K* stock:

$$K_{t+1} = (1-d)K_t + I_t$$

- where *d*= depreciation rate
- *K* stock in next period = undepreciated capital + investment

- Closed economy: $S^d=I^d$, so substitute S_t for I_t

See you next time